

## Claims

We claim:

1. A computer-implemented method for locating regions of a target image that  
5 match a template image with respect to color and pattern information, the method comprising:  
performing a color matching search through the target image in order to find one or  
more color match candidate regions, wherein the one or more color match candidate regions  
match the template image with respect to color information;  
performing a luminance pattern matching search in the one or more color match  
10 candidate regions in order to find one or more luminance pattern match candidate regions in the  
target image, wherein the one or more luminance pattern match candidate regions match the  
template image with respect to pattern information;  
wherein at least one of said color matching search and said luminance pattern matching  
search are performed using a hill-climbing technique; and  
15 wherein the one or more luminance pattern match candidate regions are useable in  
determining regions of the target image that match the template image with respect to color  
information.
2. The method of claim 1, further comprising:  
20 generating a color characterization of the template image prior to performing the color  
matching search;  
wherein said performing a color matching search comprises:  
generating a color characterization of a plurality of regions of the target image;  
comparing the color characterization of the template image with the color  
25 characterization of each of the plurality of regions; and  
generating a score for each of the plurality of regions indicating correlation  
between the color characterization of the template image and the color characterization of each  
of the plurality of regions.
3. The method of claim 2, wherein said performing a color matching search further  
30 comprises:

receiving user input specifying color matching search options;  
performing a first-pass color characterization search through the target image to find  
initial color match candidate areas;  
searching proximal regions of each said initial color match candidate area using said  
5 hill-climbing technique to find a best color match region for each area;  
calculating a color match score for each said best color match region; and  
generating a final list of color match regions based on said color match scores.

4. The method of claim 3, wherein said searching proximal regions to find said best  
10 color match region for each area using said hill-climbing technique comprises:  
using a coarse hill-climbing technique to find a coarse color match candidate region; and  
using a fine hill-climbing technique on the coarse color match candidate region to find  
the best color match candidate region.

15 5. The method of claim 3, wherein said searching comprises searching among a  
plurality of sub-regions within the proximal region, wherein said searching comprises:  
moving among the plurality of sub-regions using a coarse hill-climbing technique to  
find a coarse candidate sub-region; and  
searching proximal sub-regions of the coarse candidate sub-region by a fine hill-  
20 climbing technique to find the best color match candidate region.

6. The method of claim 2, further comprising:  
calculating a final color match score for the one or more luminance pattern match  
candidate regions, wherein, for each luminance pattern match candidate region, calculating the  
25 final color match score comprises:  
comparing the color characterization of the template image with the color  
characterization of the luminance pattern match candidate region; and  
generating the final color match score for the luminance pattern match candidate  
region indicating correlation between the color characterization of the template image and the  
30 color characterization of the luminance pattern match candidate region.

7. The method of claim 6, wherein said performing a luminance pattern matching search further comprises calculating a luminance pattern match score for each of the one or more luminance pattern match candidate regions in the target image, the method further comprising:

5 determining one or more final match regions in the target image using the luminance pattern match score and the final color match score for each of the one or more luminance pattern match candidate regions; and

providing output indicating the one or more final match regions in the target image, wherein the one or more final match regions match the template image with respect to color and  
10 pattern information.

8. The method of claim 6,

wherein, for each color match candidate region, the luminance pattern matching search comprises comparing luminance values of pixels in the template image with luminance values  
15 of pixels in the color match candidate region of the target image.

9. The method of claim 6, further comprising:

receiving user input indicating one or more colors to be masked in the color matching search;

20 modifying color bin values for the selected masked colors in the color characterizations of the template image and the plurality of regions of the target image to produce respective masked color characterizations of the template image and the plurality of regions of the target image; and

using the masked color characterizations in said color matching search.

10. The method of claim 9,

wherein said modifying color bin values comprises subtracting a value from each masked color bin value, and wherein the resultant values are adjusted to be non-negative.

30 11. The method of claim 9, further comprising:

zeroing color bin values for the selected masked colors in the color characterizations of the template image and the plurality of regions of the target image to produce respective true masked color characterizations of the template image and the plurality of regions of the target image; and

5            using the true masked color characterizations in said calculating a final color match score.

12.    The method of claim 2, further comprising:

10            calculating a hue pattern match score for the one or more luminance pattern match candidate regions;

          wherein the hue pattern match score is useable in determining one or more final match regions of the target image that match the template image with respect to color and pattern information.

15            13.    The method of claim 12,

          wherein, for each luminance pattern match candidate region, calculating the hue pattern match score comprises comparing hue values of pixels in the template image with hue values of pixels in the luminance pattern match candidate region of the target image

20            14.    The method of claim 13,

          wherein the pixels in the luminance pattern match candidate region exclude edge pixels of hue patterns in the luminance pattern match candidate region; and

          wherein the pixels in the template image exclude edge pixels of patterns in the template image.

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15.    The method of claim 12, further comprising:

          calculating a final color match score for the one or more luminance pattern match candidate regions, wherein, for each luminance pattern match candidate region, calculating the final color match score comprises:

30            comparing the color characterization of the template image with the color characterization of the luminance pattern match candidate region; and

generating the final color match score for the luminance pattern match candidate region indicating correlation between the color characterization of the template image and the color characterization of the luminance pattern match candidate region.

5           16.     The method of claim 15, further comprising:

              determining one or more final match regions in the target image using the hue pattern match score and the final color match score; and

              providing output indicating the one or more final match regions in the target image, wherein the one or more final match regions match the template image with respect to color and  
10     pattern information.

              17.     The method of claim 12, further comprising:

              providing output indicating the one or more luminance pattern match candidate regions in the target image, wherein the one or more luminance pattern match candidate regions match  
15     the template image with respect to color and pattern information.

              18.     The method of claim 12, further comprising:

              determining one or more final match regions in the target image using the calculated hue pattern match scores; and  
20     providing output indicating the one or more final match regions in the target image, wherein the one or more final match regions match the template image with respect to color and pattern information.

              19.     The method of claim 1, further comprising:

25     calculating a pattern match score for each of the one or more luminance pattern match candidate regions, wherein the pattern match score indicates a luminance pattern match correlation between a luminance pattern match candidate region and the template image;

              calculating a hue pattern match score for each of the one or more luminance pattern match candidate regions, wherein the hue pattern match score indicates a hue pattern match  
30     correlation between a luminance pattern match candidate region and the template image;

calculating a final color match score for each of the one or more luminance pattern match candidate regions, wherein the final color match score indicates a color match correlation between a luminance pattern match candidate region and the template image;

calculating a final score for each of the one or more luminance pattern match candidate regions based on the pattern match score, the hue pattern match score, and the final color match score; and

determining one or more final match regions in the target image based upon the calculated final score of each of the one or more luminance pattern match candidate regions, wherein each of the one or more final match regions matches the template image with respect to color, luminance pattern, and hue pattern.

20. The method of claim 19,

wherein, for each luminance pattern match candidate region, calculating the final color match score comprises:

comparing the color characterization of the template image with the color characterization of the luminance pattern match candidate region; and

generating the final color match score for the luminance pattern match candidate region indicating correlation between the color characterization of the template image and the color characterization of the luminance pattern match candidate region.

21. The method of claim 1, further comprising:

generating a luminance pattern characterization of the template image prior to performing the luminance pattern matching search;

wherein said performing a luminance pattern matching search comprises:

generating a luminance pattern characterization of a plurality of regions of the target image;

comparing the luminance pattern characterization of the template image with the luminance pattern characterization of each of the plurality of regions; and

generating a score for each of the plurality of regions indicating correlation between the luminance pattern characterization of the template image and the luminance pattern characterization of each of the plurality of regions.

22. The method of claim 21, wherein said performing a luminance pattern matching search further comprises:

5 searching proximal regions of each said color match candidate region using said hill-climbing technique to find a best luminance pattern match region for each color match candidate region;

calculating a luminance pattern match score for each said best luminance pattern match region; and

10 generating a final list of luminance pattern match regions based on said luminance pattern match scores.

23. The method of claim 22, wherein said searching proximal regions to find said best luminance pattern match region for each area using a hill-climbing technique comprises:

15 using a coarse hill-climbing technique to find a coarse luminance pattern match candidate region; and

using a fine hill-climbing technique on the coarse luminance pattern match candidate region to find the best luminance pattern match region.

24. The method of claim 22, wherein said searching comprises searching among a plurality of sub-regions within the proximal region, wherein said searching comprises:

20 moving among the plurality of sub-regions using a coarse hill-climbing technique to find a coarse candidate sub-region; and

searching proximal sub-regions of the coarse candidate sub-region by a fine hill-climbing technique to find the best luminance pattern match candidate region.

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25. The method of claim 22, further comprising:

determining one or more final match regions in the target image based on said final list of luminance pattern match regions;

30 wherein the one or more final match regions match the template image with respect to color and pattern information.

26. The method of claim 25, further comprising:

for each final match region found that matches the template image with respect to color and pattern information, displaying information on a graphical user interface indicating the location of the final match region within the target image.

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27. The method of claim 25, further comprising:

for each final match region found that matches the template image with respect to color and pattern information, displaying information on a graphical user interface indicating a degree to which color and pattern information of the final match region matches color and pattern information of the template image.

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28. The method of claim 22,

wherein said search of a proximal region comprises performing a plurality of iterations of luminance pattern matching in the proximal region.

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29. The method of claim 28,

wherein the plurality of iterations of luminance pattern matching are performed in a coarse to fine manner.

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30. The method of claim 29,

wherein said performing the plurality of iterations of luminance pattern matching in a coarse to fine manner uses one or more of:

sets of sample pixels with successively smaller stability neighborhood sizes; and  
sets of sample pixels with successively smaller step sizes.

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31. The method of claim 1,

wherein said performing the color matching search through the target image comprises:

determining a plurality of sample regions at which to sample color information of the target image, wherein each sample region comprises a portion of the target image;



for each of the plurality of sample regions, determining a measure of difference between color information of the sample region and the color information of the template image; and

for each of the plurality of sample regions, designating the sample region as a color match region if the measure of difference between the color information of the sample region and the color information of the template image is smaller than a threshold value.

32. The method of claim 31, further comprising:

performing a color characterization analysis of the template image; and

for each of the plurality of sample regions, performing a color characterization analysis of the sample region;

wherein said determining the measure of difference between the color information of each sample region and the color information of the template image comprises comparing information obtained in the color characterization analysis of the sample region with information obtained in the color characterization analysis of the template image.

33. The method of claim 32,

wherein the template image and the target image each comprise a plurality of pixels;

wherein the color characterization analysis performed for the template image and the color characterization analysis performed for each of the plurality of sample regions comprise:

examining color information of at least a subset of pixels;

assigning each examined pixel to a color category that corresponds to a portion of a color space;

determining information indicative of the allocation of the examined pixels across color categories; and

wherein said comparing information obtained in the color characterization analysis of the sample region with information obtained in the color characterization analysis of the template image comprises comparing the allocations of the examined pixels across color categories for the sample region and the template image, respectively.

34. The method of claim 33,

wherein the color characterization analysis performed for the template image comprises examining color information of each pixel in the template image; and

wherein the color characterization analysis performed for each of the plurality of sample regions comprise examining color information of only a subset of the pixels in the sample region.

35. The method of claim 33,

wherein the color information of the template image and the color information of the target image comprise hue, saturation, and intensity (HSI) color information;

wherein said examining color information of at least a subset of pixels comprises examining HSI information of the at least a subset of pixels; and

wherein said assigning each examined pixel to a color category that corresponds to a portion of a color space comprises assigning each examined pixel to a color category that corresponds to a portion of HSI color space.

36. The method of claim 33, wherein the color characterization analysis performed for the template image further comprises:

determining one or more dominant color categories, wherein the one or more dominant color categories are assigned a relatively larger proportion of examined pixels, with respect to other color categories of the color space.

37. The method of claim 32, wherein said comparing information obtained in the color characterization analysis of each region of the target image to information obtained in the color characterization analysis of the template image comprises:

for each dominant color category, comparing the percentage of template image pixels assigned to the dominant color category to the percentage of target image region pixels assigned to that color category.

38. The method of claim 31, wherein the target image comprises a plurality of pixels, the method further comprising:

determining a first step size to use in said determining the plurality of sample regions at which to sample the color information of the target image;

wherein said determining the plurality of sample regions comprises:

5 determining a plurality of regions of the target image at which to sample the color information of the target image, wherein the plurality of regions are each specified by windows into the target image, and wherein said windows are offset from each other by a number of pixels specified by the first step size.

39. The method of claim 1, wherein the template image and the target image each  
10 comprise a plurality of pixels, the method further comprising:

characterizing pattern information of the template image, wherein the characterizing comprises:

15 sampling the template image to determine a first plurality of sample pixels, wherein the first plurality of sample pixels comprises a subset, but not all, of the pixels of the template image;

wherein said performing a luminance pattern matching search through the target image uses the first plurality of sample pixels.

40. The method of claim 39, wherein the characterizing further comprises:  
20 performing a local stability analysis around at least a subset of the first plurality of sample pixels, wherein said performing the local stability analysis determines a second plurality of sample pixels which have a desired degree of stability, wherein the second plurality of sample pixels comprises a subset, but not all, of the first plurality of sample pixels;

25 wherein said performing the local stability analysis operates to ensure stability of each of the second plurality of sample pixels to spatial perturbations around the sample pixel; and

wherein said performing a pattern matching search through the target image uses the second plurality of sample pixels.

41. The method of claim 40,  
30 wherein said performing the local stability analysis around the at least a subset of the first plurality of sample pixels comprises:

for each sample pixel, finding a neighborhood around the sample pixel where a value of the sample pixel correlates highly with template image pixel values in the neighborhood.

5           42.     The method of claim 39,  
              wherein each of the pixels in the template image are comprised of a plurality of components; and  
              wherein said sampling the template image comprises sampling the template image in one or more component planes of the plurality of components.

10           43.     The method of claim 42,  
              wherein each of the pixels in the template image are comprised of hue, saturation, and intensity components; and  
              wherein said sampling the template image comprises sampling the template image in  
15           one or more of the hue, saturation, and intensity planes.

              44.     The method of claim 39,  
              wherein said sampling the template image comprises sampling the template image along one or more rotationally invariant paths to produce one or more sets of sample pixels; and  
20           wherein said performing the luminance pattern matching search uses the one or more sets of sample pixels to determine one or more rotated instances of the template image in the target image.

              45.     A computer-implemented method for locating regions of a target image that  
25           match a template image with respect to color and pattern information, the method comprising:  
              performing a color matching search through the target image using a hill-climbing technique in order to find one or more color match candidate regions, wherein the one or more color match candidate regions match the template image with respect to color information; and  
              performing a luminance pattern matching search in the one or more color match  
30           candidate regions in order to find one or more luminance pattern match candidate regions in the target image;

wherein the one or more luminance pattern match candidate regions are useable in determining regions of the target image that match the template image with respect to color information.

5           46. A computer-implemented method for locating regions of a target image that match a template image with respect to color and pattern information, the method comprising:

performing a color matching search through the target image in order to find one or more color match candidate regions, wherein the one or more color match candidate regions match the template image with respect to color information; and

10           performing a luminance pattern matching search in the one or more color match candidate regions using a hill-climbing technique in order to find one or more luminance pattern match candidate regions in the target image, wherein the one or more luminance pattern match candidate regions match the template image with respect to pattern information;

15           wherein the one or more luminance pattern match candidate regions are useable in determining regions of the target image that match the template image with respect to color information.

20           47. A computer-implemented method for locating regions of a target image that match a template image with respect to color and pattern information, the method comprising:

performing at least one of color matching and pattern matching of the target image using a hill-climbing technique to determine one or more candidate regions, wherein the one or more candidate regions match the template image with respect to at least one of color information and pattern information; and

providing output indicating the one or more candidate regions in the target image.

25           48. The method of claim 47,

wherein said performing at least one of color matching and pattern matching comprises performing at least one of color matching and luminance pattern matching.

30           49. The method of claim 47, further comprising:

calculating a hue pattern match score for at least a subset of the one or more candidate regions, wherein said hue pattern match score is usable to determine one or more final match regions in the target image.

5           50.    A computer-implemented method for locating regions of a target image that match a template image with respect to color and pattern information, the method comprising:

          performing a color matching search through the target image in order to find one or more first candidate regions, wherein the one or more first candidate regions match the template image with respect to color information;

10           performing a luminance pattern matching search in at least a subset of the one or more first candidate regions in order to find one or more second candidate regions in the target image;

          determining one or more final match regions in the target image from said one or more second candidate regions; and

          providing output indicating the one or more final match regions in the target image,  
15           wherein the one or more final match regions match the template image with respect to color and pattern information;

          wherein at least one of said color matching search and said luminance pattern matching search are performed using a hill-climbing technique.

20           51.    A system for locating regions of a target image that match a template image with respect to color and pattern information, the system comprising:

          a processor;

          a memory medium coupled to the processor, wherein the memory medium stores color / pattern matching software;

25           wherein the processor is operable to execute the color / pattern matching software to:

          perform a color matching search through the target image in order to find one or more color match candidate regions, wherein the one or more color match candidate regions match the template image with respect to color information; and

          perform a luminance pattern matching search in the one or more color match  
30           candidate regions in order to find one or more luminance pattern match candidate regions in the target image;

wherein at least one of said color matching search and said luminance pattern matching search are performed using a hill-climbing technique; and

wherein said one or more luminance pattern match candidate regions match the template image with respect to pattern and color information.

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52. A memory medium comprising program instructions for locating regions of a target image that match a template image with respect to color and pattern information, wherein the program instructions are executable to implement:

performing a color matching search through the target image in order to find one or more color match candidate regions, wherein the one or more color match candidate regions match the template image with respect to color information; and

performing a luminance pattern matching search in the one or more color match candidate regions in order to find one or more luminance pattern match candidate regions in the target image;

wherein at least one of said color matching search and said luminance pattern matching search are performed using a hill-climbing technique; and

wherein said one or more luminance pattern match candidate regions match the template image with respect to pattern and color information.

53. The memory medium of claim 52, wherein said program instruction are further executable to implement:

calculating a hue pattern match score for the one or more luminance pattern match candidate regions;

wherein the hue pattern match score is useable in determining one or more final match regions of the target image that match the template image with respect to color and pattern information.

54. The memory medium of claim 53, wherein said program instruction are further executable to implement:

determining one or more final match regions in the target image using the calculated hue pattern match scores; and

providing output indicating the one or more final match regions in the target image, wherein the one or more final match regions match the template image with respect to color and pattern information.

5           55.     The memory medium of claim 52, wherein said program instruction are further executable to implement:

          generating a color characterization of the template image prior to performing the color matching search;

          wherein said performing a color matching search comprises:

10               generating a color characterization of a plurality of regions of the target image;

          comparing the color characterization of the template image with the color characterization of each of the plurality of regions; and

          generating a score for each of the plurality of regions indicating correlation between the color characterization of the template image and the color characterization of each  
15 of the plurality of regions.

          56.     The memory medium of claim 55, wherein said performing a color matching search further comprises:

          receiving user input specifying color matching search options;

20               performing a first-pass color characterization search through the target image to find initial color match candidate areas;

          searching proximal regions of each said initial color match candidate area to find a best color match region for each area;

          calculating a color match score for each said best color match region; and

25               generating a final list of color match regions based on said color match scores.

          57.     The memory medium of claim 56, wherein said searching proximal regions comprises:

          using a coarse hill-climbing technique to find a coarse color match candidate region; and

30               using a fine hill-climbing technique on the coarse color match candidate region to find the best color match candidate region.



58. The memory medium of claim 56, wherein said searching comprises searching among a plurality of sub-regions within the proximal region, wherein said searching comprises:

moving among the plurality of sub-regions using a coarse hill-climbing technique to  
5 find a coarse candidate sub-region; and

searching proximal sub-regions of the coarse candidate sub-region by a fine hill-climbing technique to find the best color match candidate region.

59. The memory medium of claim 52, wherein said program instruction are further  
10 executable to implement:

calculating a final color match score for the one or more luminance pattern match candidate regions, wherein, for each luminance pattern match candidate region, calculating the final color match score comprises:

comparing the color characterization of the template image with the color  
15 characterization of the luminance pattern match candidate region; and

generating the final color match score for the luminance pattern match candidate region indicating correlation between the color characterization of the template image and the color characterization of the luminance pattern match candidate region.

60. The memory medium of claim 59, wherein said performing a luminance pattern matching search further comprises calculating a luminance pattern match score for each of the one or more luminance pattern match candidate regions in the target image, the method further comprising:

determining one or more final match regions in the target image using the luminance  
25 pattern match score and the final color match score for each of the one or more luminance pattern match candidate regions; and

providing output indicating the one or more final match regions in the target image, wherein the one or more final match regions match the template image with respect to color and pattern information.

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61. The method of claim 52, wherein said performing a luminance pattern matching search further comprises:

searching proximal regions of each said color match candidate region using said hill-climbing technique to find a best luminance pattern match region for each color match candidate region;

calculating a luminance pattern match score for each said best luminance pattern match region; and

generating a final list of luminance pattern match regions based on said luminance pattern match scores.

62. The method of claim 61, wherein said searching proximal regions of each said color match candidate region using said hill-climbing technique comprises:

using a coarse hill-climbing technique to search a proximal region of the color match candidate region to generate a coarse luminance pattern match candidate region; and

using a fine hill-climbing technique on the coarse luminance pattern match candidate region to find the best luminance pattern match candidate region.

63. The method of claim 61, wherein said searching a proximal region comprises searching among a plurality of sub-regions within the proximal region, wherein said searching comprises:

moving among the plurality of sub-regions using a coarse hill-climbing technique to find a coarse candidate sub-region; and

searching proximal sub-regions of the coarse candidate sub-region by a fine hill-climbing technique to find the best luminance pattern match candidate region.

64. The memory medium of claim 52, wherein said program instruction are further executable to implement:

providing output indicating the one or more luminance pattern match candidate regions in the target image.

65. A memory medium comprising program instructions for locating regions of a target image that match a template image with respect to color and pattern information, wherein the program instructions are executable to implement:

performing a color matching search through the target image using a hill-climbing  
5 technique in order to find one or more color match candidate regions, wherein the one or more color match candidate regions match the template image with respect to color information; and

performing a luminance pattern matching search in the one or more color match candidate regions in order to find one or more luminance pattern match candidate regions in the target image;

10 wherein said one or more luminance pattern match candidate regions match the template image with respect to pattern and color information.

66. A memory medium comprising program instructions for locating regions of a target image that match a template image with respect to color and pattern information, wherein  
15 the program instructions are executable to implement:

performing a color matching search through the target image in order to find one or more color match candidate regions, wherein the one or more color match candidate regions match the template image with respect to color information; and

performing a luminance pattern matching search in the one or more color match  
20 candidate regions using a hill-climbing technique in order to find one or more luminance pattern match candidate regions in the target image;

wherein said one or more luminance pattern match candidate regions match the template image with respect to pattern and color information.

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